TROPICAL DISTURBANCES ON THE NORTH ATLANTIC OCEAN AND GULF OF MEXICO, SEPTEMBER 1937

By WILLIS E. HURD

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Five disturbances of tropical origin were charted in North Atlantic waters (including the Gulf of Mexico) during September 1937. A sixth disturbance may be mentioned in connection with those of September, as it originated on the 30th. Two of the six were confined almost entirely to the Gulf of Mexico, and were of only minor intensity. Of the remaining four, one, of moderate energy, passed up the east coast of the United States and entered the open ocean beyond Newfoundland; the other three, two of which developed known hurricane intensity, originated to the eastward of the Leeward Islands and moved generally to the northward. Two of them entered the continent at Nova Scotia, while one, with a northeasterly inclination, entered high latitudes wholly away from land.

The tracks of all these disturbances are shown in the accompanying figure, numbered I to VI, chronologically.

Disturbance of September 9–14, 1937.—(Track I.) As early as September 6 disturbed conditions existed in the vicinity of 14° N., 44° W., but it was not until the 9th that a more positive development was reported. At 4 a. m. of that date a radio message was received from the French motorship *Fort Royal*, in latitude 18°40′ N., longitude 55°06′ W., reported a barometer of 29.71, falling rapidly, with gusty east winds, heavy rain, and very heavy seas. Four hours later, with the ship near 19° N., 55° W., the wind had changed to south, force 7, while the barometer had fallen to 29.65. At regular p. m. observation of the 9th a southeast gale of force 9, barometer 29.80, was reported by another ship in 20°12′ N., 53°54′ W.

At 10 a. m. of the 10th, in latitude 21°30′ N., longitude 57°12′ W., the British steamer *Winamac* had a barometer reading of 29.39 inches, with a north-northeast gale of

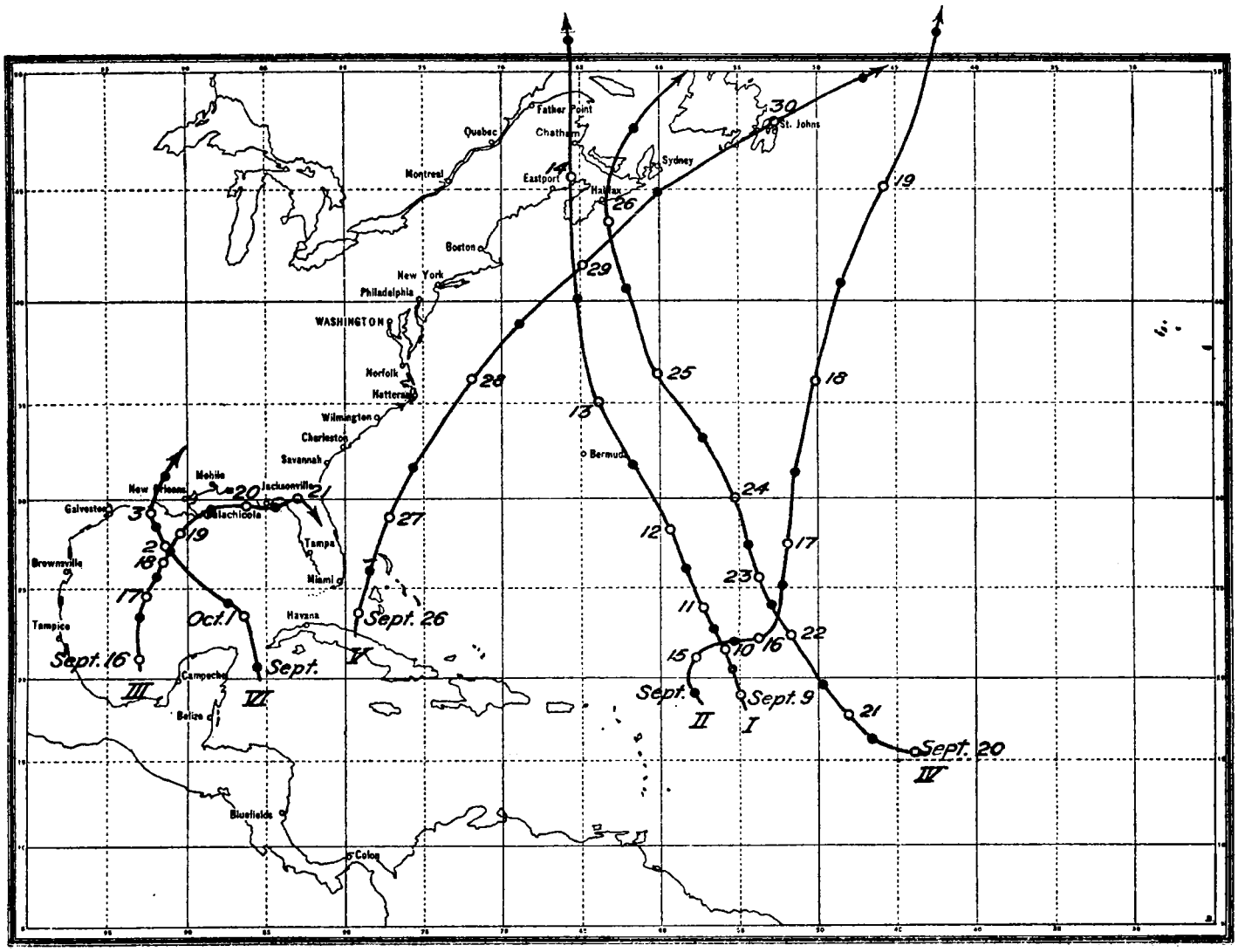

FIGURE 1.—Approximate tracks of tropical disturbances, September 1937.

force 10. At local noon the wind had changed to south-southwest, force 9, with rising barometer. At 6 p. m., of the 10th the Dutch steamer *Telamon.* in 24°21′ N., 57°16′ W., had an east-southeast gale of force 8, barometer 29.68.

On the morning of the 11th the storm center was approximately at 24° N., 57½° W., moving north-northwestward. Ship reports were few, but an 8 a. m., local time, observation from the German steamer *Vegesack* gave a northeast wind of force 9, barometer 29.77, near 25° N., 60° W.

During the remainder of the 11th and through the 12th, on the night of which the storm passed east of Bermuda, little is known of the storm's intensity beyond that indicated by a few ships which reported moderate to fresh gales well outside the center. At 2:30 a. m. of the 13th, however, the British steamer *Cadillac*, in 33° 50′ N., 63° 20′ W., had a north gale of force 9 and a barometer of 29.30 inches, which indicated the center to be a short distance to the eastward, and still moving in a north-northwesterly direction.

During the night of the 13–14th the storm, then progressing almost due northward, showed little change in depth, with the British steamer *Cyrus Field*, in 42° 50′ N., 65° 48′ W., at 5 a. m., reporting a barometer of 29.30 inches, wind north-northwest, force 7. About 2 hours earlier this ship, northbound, had highest wind force, 9, from the northeast. The strongest gale reported on the 14th was at 1 a. m., when the British steamer *Darcoila* had a wind of force 10 from the south-southwest, barometer 29.30, in 43° 20′ N., 64° 50′ W. At 8 a. m. of the 14th the center, after crossing western Nova Scotia, passed near Eastport, Maine, where the barometer read 29.48 inches. Thereafter the disturbance moved rapidly northward across New Brunswick and at 8 p. m. of the 14th lay over the lower St. Lawrence Valley.

The most dramatic incident in connection with this entire disturbance was the disappearance of the British racing yacht *Endeavor I*, after breaking loose from tow in the storm on the 13th, when about 200 miles east of the Nantucket Lightship, with 18 persons on board. Several days' search for the missing vessel failed to disclose her whereabouts until the 22d, when she was sighted about 260 miles from Fastnet Rock.

Advisory messages regarding this disturbance were first issued from the Forecast Center at San Juan, P. R., on the 9th and continued until the 10th. Thereafter, continuing through the 12th, advisories were issued by the forecaster on duty at Jacksonville. At 10 p. m. of the 13th the Washington forecaster ordered northeast storm warnings on the New England coast from Boston to Eastport. These were hauled down on the 14th after the passage of the storm inland.

Hurricane of September 14–19, 1937.—(Track II). A tropical storm of near-hurricane intensity when earliest reported appeared near midday of the 14th near 20° N., 57° W. At 1 p. m., local time, of that date, the Norwegian motorship *California Express* experienced a southeast gale of force 11, barometer 29.57, in 20°12′ N., 57°18′ W. At 7 p. m., E. S. T., the ship had a northeast gale of force 9, barometer 28.72, near 20° N., 58° W. At 1 a. m. of the 15th, in 20° 39′ N., 57°48′ W., she reported a barometer down to 28.20 inches, with an east-northeast gale of force 9. At 7 a. m., E. S. T., near 21½° N., 57½° W., the wind at ship had changed to northeast, force 7, barometer 28.29. At the same time the British S. S. *Glendene*, near 22° N., 58° W., had a northeasterly wind of force 8, barometer 29.68. The storm appeared to be moving slowly during the 17th, at first in a northerly, then in a northeasterly to east-northeasterly direction.

At the morning observation of the 16th no very low barometer was in evidence, but near-hurricane winds continued, with the British motorship *Atheprince* reporting a northeast gale of force 11, barometer 29.41, near 22½° N., 54° W. During the afternoon of the 16th the storm took a north-northeast course. There were then few reporting ships in the immediate vicinity of the center, one of the nearest being the Dutch steamer *Crynssen* which, near 22° N., 51° W., had a southwest wind of force 7, barometer 29.89. Early in the morning of the 17th, according to a report received at Bermuda, the Norwegian motorship *Teddy* passed very close to the center, in about 26°50′ N., 51° 40′ W., with barometer 28.60 and winds of force 11 to 12 shifting from southeast to northeast and northwest, with heavy rain and seas. Later, at morning observation of the 17th, the French S. S. *Carimare*, near 27½° N., 52½° W., had a north wind of force 9, barometer 29.50, and close by to the eastward a ship (name not reported) had a gale of like force from the northeast, barometer 29.09. The storm at that time was centered close by and moving more rapidly northward.

During the 18th the cyclone appeared to have gathered energy. At about 3 a. m., local time, the American steamer *Otho*, near 34° N., 50° W., encountered a southeasterly hurricane, changing at 5 a. m. to a north-northwest hurricane, lowest pressure 28.54. At 11:30 a. m., near 35° N., 48° W., the British steamer *Oropesa* had a hurricane wind from southeast, barometer 29.53. Early in the afternoon of the 18th the Italian motorship *Maria*, near 37½° N., 45½° W., met a south gale of force 9, barometer 29.92 and at 4 p. m., near 36½° N., 46½° W., the Belgian motorship *Lubrafol* had a like gale, barometer 29.80.

By night of the 18th the hurricane, then moving on a north-northeast course, was centered near 40° N., 49° W.

The intensity of the storm on the 19th is well shown by excellent special reports furnished by the American steamer *City of Newport News*, Capt. Robert L. Wright, to the United States Hydrographic Office, and the Dutch steamer *Bilderdyk*, Capt. C. H. P. Coster, to the United States Weather Bureau. The S. S. *City of Newport News*, bound from Havre toward Norfolk, after encountering severe gales on the eastern side of the hurricane during the morning, ran into the calm center at 46° 20′ N., 46° W., at 9:20 a. m., barometer 28.65. "We were treated," said Captain Wright, "to a perfect exhibition of the old story—'the eye of the storm'—the wind dropped from force 11 to a dead calm, the sea suddenly lost its strength, and long and confused swells continued running from the south-southwest. At that time the sun came out blindingly—a sickly yellow—and occasional patches of blue sky appeared momentarily around its vicinity. This condition lasted for 18 minutes." The ship's lowest barometer, 28.55, was read at about 9:37 a. m., local time, when the wind shifted to northwest. The highest wind on the ship was from the northwest, force 12.

The Holland-America Line steamer *Bilderdyk* was en route from Rotterdam to New York; her noon position on the 19th was at 47°29′ N., 40°06′ W. At 3 p. m., according to Captain Coster's report, the ship had run into the storm, with a southeasterly wind of force 9. The gale increased to a south-southeast hurricane at 5 p. m. and so continued until 6:30 p. m., when it lightened to force 6, near the storm center, and changed to south-southwest, thereafter increasing to force 11 from the southwest. The lowest barometer on ship was 28.93, with the instrument fluctuating by about a millimeter between 6 and 6:30 p. m., local time.

Thereafter, the storm passed rapidly into high northern latitudes and on the 22d was central near Iceland.

During the early stages of this disturbance in low latitudes, advisory messages were issued concerning its movements from the Forecast Centers at San Juan and Jacksonville.

Disturbance of September 16–21.—(Track III.) Somewhat disturbed weather conditions occurred over the southwestern part of the Gulf of Mexico on September 16, with slight lowering of pressure and evidence of a cyclonic circulation. The center of the depression was near 21° N., 93° W., in the morning and about 3° farther north 12 hours later. The highest wind reported in connection with it during the day was from the northwest, force 5, near 23° N., 94½° W., at 1 p. m., local time.

The disturbance moved slowly in a north-northeasterly direction with little general change in energy during the 17th and at 6 p. m., E. S. T., was central at approximately 25½° N., 92° W., but the weather was unsettled over much of the northwestern Gulf. At 10 a. m., according to a belated report, the American steamer *Oliver Olson* met a local gale of force 10 from the northeast, barometer 29.74, in 26°55′ N., 91°37′ W. This was the only high wind reported from the vicinity of the disturbance during the day.

On the 18th and 19th the region was more generally disturbed and several ships in the northern Gulf reported winds of force 7 on both dates. The highest reported at sea in the 2 days was of force 8, from the southeast, barometer 29.72, experienced by an unidentified vessel near 28° N., 89° W., at 7 p.m. of the 18th. At 3:30 p. m. of the 19th the center turned more to the east and passed over Port Eads, with barometer reading of 29.64, the lowest recorded during the existence of the depression. Quoting from the report of R. A. Dyke, forecaster in charge at New Orleans:

> The wind at Port Eads on the 19th veered from south at 7:30 a. m. through west at 1:30 p. m. to north at 4 p. m. An incomplete wind velocity record at Port Eads gives a 5-minute maximum of 34 miles per hour at 3:28 p. m. and an extreme velocity of 41 at 3:32 p. m., both on the 18th.
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> Winds at Pensacola were highest on the 19th, with maximum of 28 miles per hour from the south. Winds at Apalachicola on the 20th were from south and southeast to 10 a. m. and veered through south and southwest to north at 3 p. m. The lowest pressure was 29.79 at 2:30 p. m. on the 20th and the highest wind was 30 miles per hour from the south at 5:28 a. m. on the 20th.

The depression moved in a general easterly direction across the extreme upper part of the eastern Gulf during the late 19th and the 20th, and disintegrated over northern Florida on the 21st. The average rate of movement along the entire track was about 9 miles an hour. No damage of importance resulted from the disturbance, although some injury was done to highways from the heavy rains south of Tallahassee.

During the 17th to 20th storm advisories and warnings were issued from the Weather Bureau office at New Orleans at frequent intervals.

Hurricane of September 20–26, 1937.—(Track IV.) Radio reports from ships in low latitudes early on the 20th showed the existence of an already well-developed storm of considerable extent with center in approximately 15° N., 44° W. At 9 a. m. the British steamer *City of Bataria* reported a southeast gale of force 10, barometer 29.60, in 18°06′ N., 44°15′ W., and at 10 a. m. the British motorship *Caprella* reported a southwest gale of force 11, barometer 29.48, in 14° N., 43° W.

On the 21st no ships appeared to be in the near neighborhood of the center of the disturbance, but at about 9 a. m., local time, an unknown vessel near 23° N., 49° W., reported a southeast wind of force 7, barometer 29.82. Twelve hours later the American steamer *Cliffwood*, in the same position, had a similar wind, barometer 29.86.

On the morning of the 22d reports from the French steamer *Marigot* and another vessel, unknown, located the center with closer definiteness, and showed that the storm was moving in a northwesterly direction. The *Marigot* had a west gale, force 8, barometer 29.65, near 21½° N., 54° W., and the other ship, a northwest wind of force 9, barometer 29.29, near 22½° N., 52½° W. In a special mail report later received from the *Marigot*, a northwest wind of force 10 was noted as experienced at about 2 a. m., local time, barometer 29.19 (uncorrected), near 22½° N., 52⅔° W. At regular p. m. observation of the 22d the wind reported by a ship in the storm area was of force 10, from the northeast, barometer 29.53, near 25° N., 54° W.

During the 23d the storm continued to move slowly northwestward, accompanied by strong to whole gales, lowest reported barometer 29.12, within the region 26°–28° N., 52°–56° W.

On the 24th the disturbance moved with greater rapidity. The center at 7 a. m., E. S. T., was near 30° N., 55° W., accompanied by heavy rains and local gales, a northwest wind of hurricane force being reported by the German Steamer *Nordenham*, barometer, 29.44, near 29½° N., 57° W. At 9 a. m., local time, an unidentified ship in 31°36′ N., 54°48′ W., had an east gale of force 10, barometer 29.29. During the day the storm center passed at a distance of several hundred miles to the eastward of Bermuda, and on the morning of the 25th was northeast of the island, centered near 36½° N., 60° W. At evening observation of the 25th the center had moved to about 40½° N., 62½° W., with lowest pressure 28.94 inches, and strong winds to gales of force 10 blowing over the surrounding sea.

In crossing Nova Scotia during the 26th, the storm recurved into a northeasterly direction, crossed northern Newfoundland near the Strait of Belleisle during the night of the 26–27th, and by the 30th was over Iceland.

Ample advisories and warnings of this disturbance were issued, first, on the 20th, from San Juan, P. R.; then from Jacksonville, Fla., on the 22d to 24th; and from Washington, D. C., on the 25th and 26th. At 10:10 a. m., E. S. T., of the 25th, northeast storm warnings were ordered along the New England coast from Block Island to Eastport, and whole gale warnings along the east Maine coast at 6:50 p. m. These were continued until 9:30 a. m. of the 26th, at which time the storm was over Nova Scotia with a north-northeasterly trend in direction.

Disturbance of September 26–30, 1937.—(Track V.) Slight evidences of a cyclonic circulation appeared between the central north coast of Cuba and the Bahamas on the morning of September 26. The disturbed condition moved north-northeastward as a very shallow depression, accompanied by light winds, and at 7 p. m., E. S. T., of the 27th was central near 31½° N., 75½° W. Its course thereafter curved more into northeasterly.

On the morning of the 28th the center lay at some distance east of the Virginia Capes, continuing shallow and poorly developed. At this time, however, with high pressure on the west, north, and east, the wind circulation became more energetic and winds of force 7 occurred on its west and north quadrants. At 4 a. m. of the 28th the American steamer *Gulfhawk*, in 34°40′ N., 75°27′ W., had a north-northeast wind of force 7, barometer 29.83 inches. Later in the day this ship experienced a northeast gale of force 8, the highest wind velocity reported by a ship in connection with the disturbance as it moved up the coast.

Thereafter, the center of the deprsesion continued at some distance from the coast until the 29th when it

skirted Nova Scotia close to the southward. On the morning of the 30th it crossed southeastern Newfoundland and late in the day merged with an extratropical cyclone in the high latitudes of the North Atlantic.

Relative to this disturbance, an advisory warning was issued by the Forecast Center at Jacksonville at 10 a. m. of the 27th, and storm warnings were ordered hoisted on the 28th from the Virginia Capes to Eastport, Maine. The latter order was issued by the Washington Forecast Center.

Disturbance of September 30–October 3, 1937.—(Track VI.) Slightly threatening conditions appeared over the southern part of the Gulf of Mexico and the western Caribbean Sea on the afternoon of September 30, with some evidences of cyclonic circulation centered a little south of the Yucatan Channel.

At 6 a. m., local time, of October 1 the center of the condition appeared to be at approximately 23½° N., 86° W. No wind exceeding force 6 occurred there during the day. The center moved very slowly northwestward between 6 a. m. and 6 p. m., but with much greater rapidity from then until the morning of October 2, when it lay near 27½° N., 91° W. The Honduran steamer *Morazan* reported a barometer of 29.62, wind southeast force 3, near this position. This pressure reading is the lowest of record in connection with the disturbance.

The center of the LOW continued to move toward the northwestward until the night of the 2d, when it turned toward the north and entered the Louisiana coast at Atchafalaya Bay at about noon of the 3d.

Only one report of a gale wind connected with the disturbance in mid-Gulf is now at hand. This was experienced by the American steamer *Gulfprince*, from east-southeast, force 8, barometer 29.93, in 26°36′ N., 88°12′ W. at 7 a. m., local time, of October 2, at a considerable distance to the eastward of the center at that time. It may be mentioned, however, that at about 9 p. m. of September 30 the American steamer *Seminole* reported a northeast gale of force 8 in the vicinity of 27° N., 88° W., at that time far to the northward of the center of the unsettled area. On October 1, it may be mentioned further, a second LOW of some energy showed signs of developing in the Yucatan Channel, and at about noon, local time, the Honduran schooner *Racer* reported a gale of force 10 off the western end of Cuba. This secondary LOW deteriorated rapidly, however, and later merged with the primary LOW to the northward.

From late on September 30, until the principal LOW went inland in Louisiana on October 3, frequent advisory messages were issued by the forecaster at New Orleans. On October 1 storm warnings were ordered along the coast from Panama City, Fla., to Morgan City, La., and were extended at night as far eastward as Carrabelle, Fla., and on the 2d from Carrabelle to Port O'Connor, Tex. All warnings were lowered on the 3d.

NOTES AND REVIEWS

Note on H. C. Huang's Investigations of Frontogenesis in the North Pacific. By PAT J. HARNEY. Two years ago R. W. Richardson presented the results of his study of storm tracks and their relation to the frontal zones and to the distribution of air masses over the North Pacific Ocean before the Association of Pacific Coast Geographers at Los Angeles. His curves of "cyclone frequency" were subsequently published in the MONTHLY WEATHER REVIEW in his article "Winter Air Mass Convergence in the North Pacific." [1]

These curves have recently been used in checking the calculated position of the Polar Front over the North Pacific by H. C. Huang of the National Central University of Nanking, China. While a graduate student of the California Institute of Technology, Huang determined the regions of frontogenesis over the North Pacific in the manner developed by Petterssen; [2] the results form part of a thesis at the California Institute and will subsequently be published by the National Research Institute of Meteorology at Nanking, China. The object of this note is to call attention to the results of these two studies of weather over the North Pacific, which give a useful check on the theoretical methods advanced by Petterssen.

For answering some of the questions on the location of the Polar Front in the Far East two of the charts for the winter season from his paper, Frontogenesis in the Far East, are here reproduced.

A brief comment on the method may be appropriate. Starting from the concept that frontogenesis will occur where the motion is such as to increase the concentration of iso-alpha lines (here representing temperature) until a marked discontinuity exists, the formula correlating the motion of the air and the properties of the iso-alpha field, as developed by Petterssen, may be written,

$$F=a(\cos 2\psi-\cos 2\psi')|\nabla\alpha|$$

where F, the frontogenetical function, is a product of a, the dilatation term of the field of motion (in which ψ is the angle a tangent to the isotherms makes with the dilatation axis or deformation axis of outflow and ψ' is the angle the line $F=0$ makes with the dilatation axis) and $|\nabla\alpha|$, the magnitude of the ascendant of the property α.

To evaluate the function F over the North Pacific, Huang combined the streamlines constructed by W. Werenskiold,[3] for this season with the surface-wind data available from his country, and located the hyperbolic streamline patterns which indicated the existence of the deformation fields shown on figure 1. The superposed isothermal field gave values of $|\nabla\alpha|$, which together with the graphically determined terms above listed were used to plot a field of F. The line of frontogenesis found on figure 2 represents the maximum of this field of F.

In discussing this line of frontogenesis Huang says:

> * * * the region of maximum cyclone frequency is quite far removed from the Pacific Polar Front as determined by V. Bjerknes and his coauthors in the book *Physikalische Hydrodynamik*. Actually Richardson's diagram places the storm tracks along the computed frontogenetic line given above, rather than along the deformation axis indicated in the above reference. These two lines represent different things and do not necessarily have to follow each other closely. The deformation axis is formed by the field of motion only, while the frontogenetic line is determined from the frontogenetic function F * * * which has the real importance in determining the zone of frontal activity.
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> When the two are not coincident with each other as is the case when the maximum $|\nabla\alpha|$ zone does not fall along the deformation axis, or when the angle is such that it does not give a large positive value of F along the axis, the actual frontal activity or the resultant cyclone tracks cannot coincide with the deformation axis of the field of motion. This is just what happens over the Pacific Ocean in the winter season when the cyclonic tracks and the deformation axis denoted in *Physikalische Hydrodynamik* are quite widely separated. The characteristics and the real importance of a frontogenetic line are thus further established by this interesting example.

[1] MONTHLY WEATHER REVIEW, vol. 64, No. 6, pp. 199–203, June 1936.
[2] Contribution to the Theory of Frontogenesis, Sverre Petterssen, Geofysiske Publikationer, vol. XI, No. 6, Oslo 1936.
[3] Mean Monthly Air Transport over the North Pacific Ocean, W. Werenskiold, Geofysiske Publikationer, Vol. II, No. 9, Oslo 1922.